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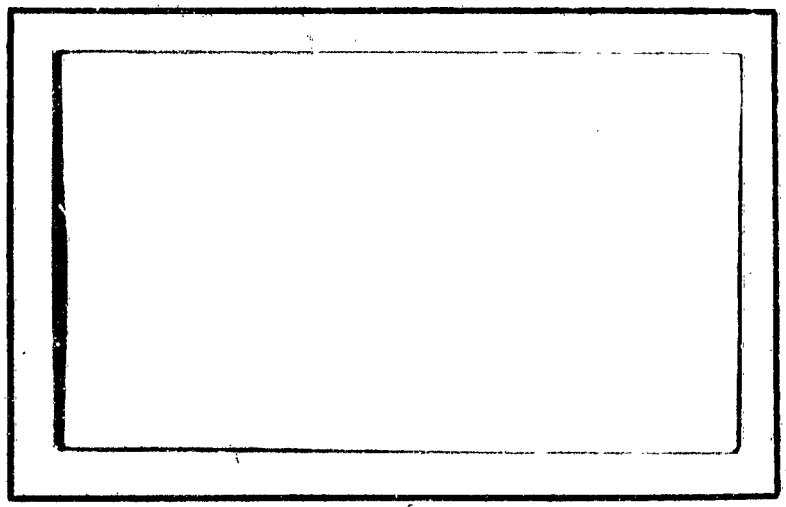
WOODS HOLE OCEANOGRAPHIC INSTITUTION



WOODS HOLE, MASSACHUSETTS

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts

Reference No. 51-93

Hydrographic Survey in the Boston Area

HAZEL III - Cruise 2

Interim Report No. 4

Submitted to the Geophysics Branch

Office of Naval Research

Under Contract N6onr-27712 (NR-084-008)

November 1951

APPROVED FOR DISTRIBUTION _____

Director

The Contractor shall furnish the necessary personnel and facilities for and, in accordance with any instructions issued by the Scientific Officer or his authorized representative, shall conduct an oceanographic investigation of Boston Harbor.

Introduction

The second oceanographic cruise to the Boston area in the Inshore Survey Program was carried out during the period 19 - 30 June, 1951. The object of the cruise was to observe, in the area and along the sections of primary interest, progressive change in the distribution of temperature, salinity ~~and transparency~~ since the preceding measurements taken in May; and to obtain some measurements of the change in distribution of temperature and salinity during the tidal cycle at two places, i.e. between Deer Island and Long Island and between Castle Island and Governors Island. In addition bacteriological studies were made in cooperation with a WHOI - U.S. Public Health Service contract investigating the survival and distribution of coliform organisms in the sea.

The locations of bathythermograms and of surface and bottom salinity samples in Massachusetts and Cape Cod Bays and the locations of stations in the Boston Area are shown in Figure 1. Salinity samples were collected at the surface, mid-depth and bottom at each station, in addition to bathythermograms and black and white Secchi disc measurements of transparency. Oxygen samples were taken at the three depths at some of the stations. All together, 128 bathythermograms were obtained and 103 stations were occupied at 32 positions.

Temperature and Salinity at the Surface

The distribution of temperature at the surface is shown in Figure 2. The range in temperature was from 57 to 65°F. The warmest water occurred up the rivers and over the shallow bays. Water warmer than 60°F extended as far east as the Light Vessel and well off shore from Plymouth and Scituate. The eastern half of Cape Cod Bay was likewise warmer than 60°F. The lowest temperatures occurred at the southwestern corner of Cape Cod Bay and along the south side of Cape Ann.

The distribution of salinity at the surface is shown in Figure 3. Maximum salinity, slightly more than 31.0 °/oo, occurred in the eastern part of Cape Cod Bay and south of Cape Ann. A salinity minimum of less than

30.6 °/oo occurred east of Plymouth. East of Deer Island the salinity was greater than 30.4 and less than 31.0 °/oo. The minimum salinity observed in the Inner Harbor was 28.4 °/oo.

Temperature Sections across Cape Cod and Massachusetts Bays

The distribution of temperature along the sections in Figure 1 are shown in Figure 4. Strong thermoclines were present throughout the area. In Section I, across the shallow southern portion of Cape Cod Bay, the thermocline was the weakest of the several sections traversed, due possibly to the shallow depth and to tidal stirring. In other sections the negative gradient for the upper 100 feet was about 6°F per 50 feet. Below 100' the gradient was less strong, being between 3 and 4°F per 50 feet. In general the water at the bottom had increased in temperature 4 to 6°F since the measurements seven weeks earlier, whereas the temperature at the surface had increased about 12°F.

Distribution of Temperature, Salinity, Density, Sound Velocity, and Dissolved Oxygen in Boston Harbor and Approaches

The distribution of temperature, salinity, density and sound velocity for a south-north section, Minots Light - Manchester, are shown in Figure 5. The temperature decreased with depth approximately 8°F per 50 feet in the upper 50 feet, 5°F per 50 feet in the next 50 feet, and less than 2°F per 50 feet between 100 and 150 feet. Salinity increased nearly 1.5 °/oo between the surface and 100 feet with a very slight increase below that depth. Density increased between 2 and 2.5 units of σ_t between the surface and 150 feet. Sound velocity decreased with depth from approximately 4920 feet per sec, to approximately 4840 feet per sec. at 150 feet. The velocity gradient was strongest at mid-depths.

The profiles essentially normal to this one, i.e., Mystic River through the Inner Harbor, President Roads, North Channel and easterly to the longitude of

Boston Light Vessel are shown in Figure 6. Temperature decreased with depth in the Inner Harbor and in President Roads at a rate greater than 3°F per 50 feet. In North Channel the gradient was considerably greater, especially at mid-depth, where a maximum gradient of 6°F per 20 feet was encountered. At the eastern end of the profile the gradient was nearly uniform from surface to bottom, being about 12°F per 100 feet.

The salinity increased with depth, there being a very strong gradient, greater than 2 °/oo in 50 feet, in the upper reaches of the Inner Harbor. This strong gradient, due chiefly to river effluent, petered out in the vicinity of Deer Island. East of Deer Island a very weak salinity gradient occurred near the surface, with a somewhat stronger one lying between 25 and 60 feet.

The density profile very closely paralleled the salinity profile with a strong density increase with depth near the surface in the Inner Harbor. This gradient diminished down the harbor to Deer Island, where it increased again at greater depth due to an intrusion of Massachusetts Bay water.

The sound velocity profile indicated that the decrease in temperature with depth in the Inner Harbor was nearly compensated for by the salinity increase with depth, in that the velocity difference between the surface and the bottom in the Inner Harbor and President Roads was less than 20 feet per sec. However, east of Deer Island the strong temperature gradient combined with the relatively weak salinity gradient produced a strong negative sound velocity gradient. This gradient was strongest in a 30 foot stratum centered at 50 feet. The sound velocity decreased more than 60 feet per sec. between the surface and the bottom in this region.

The distribution of dissolved oxygen ranged from less than 40% saturation at the surface at two places in the Inner Harbor to a little over 100% saturation throughout the water column near Deer Island, with slightly less than 100% saturation near the bottom in North Channel.

Variations in the Distribution of Temperature and Salinity with Respect to the Tidal Cycle

In an attempt to study the variations in temperature and salinity with respect to the tidal cycle a series of three stations were occupied once an hour between Deer Island and Long Island on 27 June, 1951, and a series of four stations were occupied between Castle Island and Governors Island on 29 June, 1951.

The distribution of temperature, salinity and current velocity and direction are indicated in Figure 7 for the measurements at the central station in the Deer Island - Long Island section (Station Bh). It is noted that during the tidal cycle the temperature of the water column varied from >59°F to <63°F at the surface and from from <54°F to <58°F at the bottom, a difference of 4°F. The change of salinity was from <31.0 °/oo to <30.0 °/oo at the surface and from 31.25 °/oo to <31.0 °/oo at the bottom. These excursions in temperature and salinity are about what one would expect from an inspection of Figure 6 and with knowledge of the fact that the tidal currents, with maximum values of >1.5 knots, Figure 7, extended all the way to the bottom. The tidal excurtions appear to be approximately equivalent to the station spacing along the section, Figure 6, or about 0.6 miles.

The distribution of temperature, salinity and current velocity and direction for one of the stations (Bf) in the Castle Island - Governors Island section are indicated in Figure 8. Here the surface temperature varied from <61°F to 63°F at the surface and remained at >59°F at the bottom. The salinity varied from about 30.4 °/oo to 29.8 °/oo at the surface and remained within 0.1 °/oo of 30.8 °/oo at the bottom. These are variations in the distribution of temperature and salinity commensurate with the longitudinal distribution of these variables in this part of the estuary, where the tidal currents extend all the way to the bottom and reach maximum velocities of about 0.7 knots.

Transparency

Transparency as measured by a Secchi disc in-

creased from 4.5' at the Mystic River to 6' at President Roads, then decreased to 4' off Deer Island. Values of 10 to 15' were obtained in Broad Sound. Along the Minots to Manchester section, Secchi disc measurement ranged from 11 to 20 feet with the greater values near the center of the section. The black disc could be seen roughly one third to one half as far as the white disc.

Attendant Precipitation and Stream Flow

Precipitation and stream flow data for New England are available from the Geological Survey Water Bulletin for June, 1951. Precipitation was below normal throughout the district during June, being 2.67 inches for Massachusetts, or 76% of normal.

Stream flow averaged slightly above normal in the southern portion of the district and was consistently below normal in the northern portion. Hence we might presume the stream flow of the rivers tributary to be roughly about normal.

Ground water levels showed a seasonal decline during June. The water table was above average in eastern Massachusetts. The water level was up 0.96' from the June average. The net change in Middlesex County was -0.65 feet since May, and +2.25 feet since last June.

Bacteriological Studies

A partial result of the investigations by the bacteriologists on Cruise 2 is a plot of the Most Probable Number of Coliform Bacteria at the surface at high water at various points in Boston Harbor between the confluence of the Mystic and Chelsea Rivers and the sewer outfall at Deer Island, Figure 9. This figure clearly shows that the largest source of the contamination of Boston Harbor by coliform organisms is the sewer outfall at Deer Island with another large source in the Inner Harbor. The Charles and Mystic Rivers are known to have high coliform counts.

List of Figures

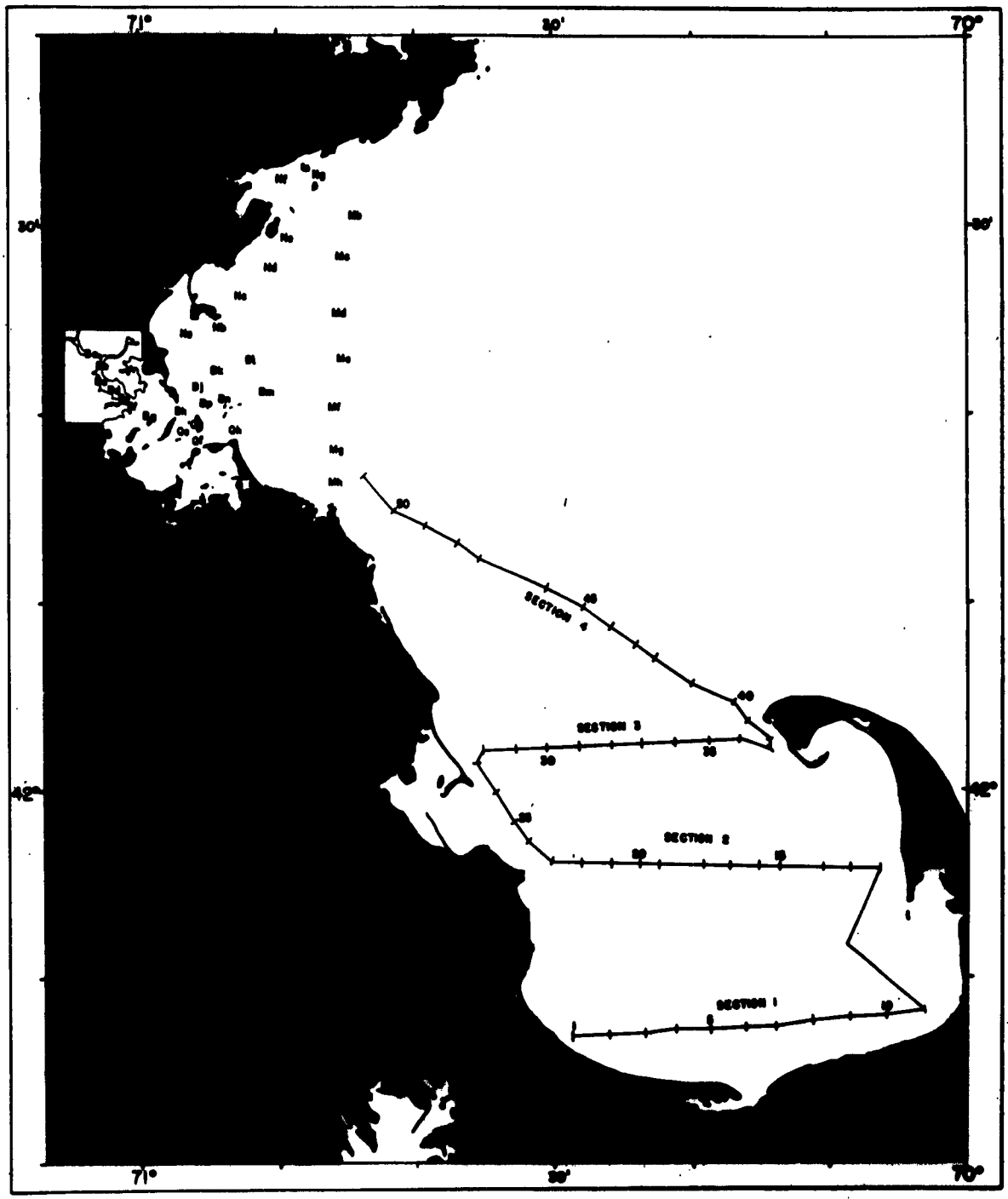
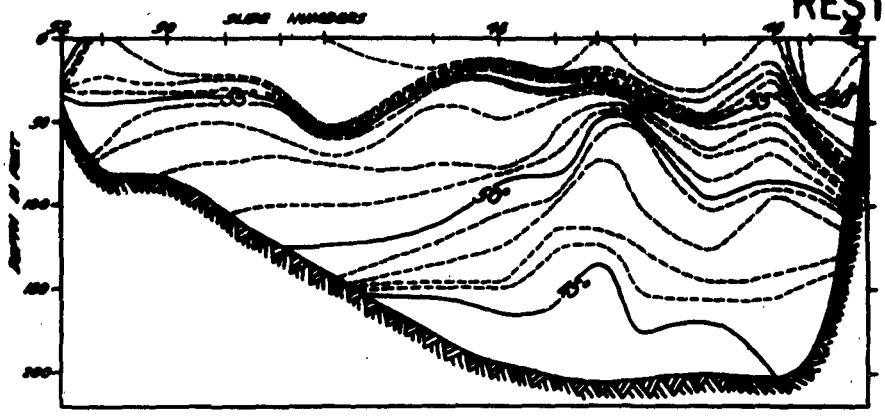


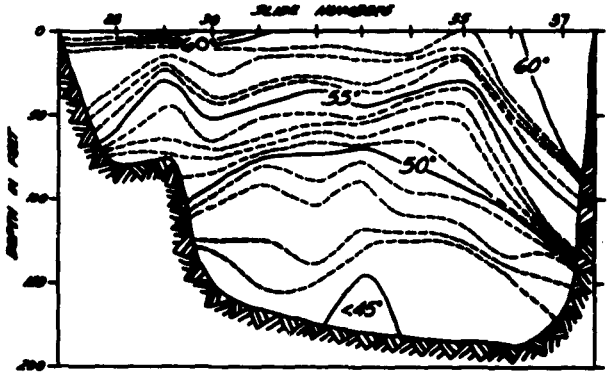
Fig. 1 Track chart and station locations. HAZEL III - Cruise 2, June 1951.

Fig. 2 Distribution of temperature (°F.) at the surface.
HAZEL III - Cruise 2, June 1951.

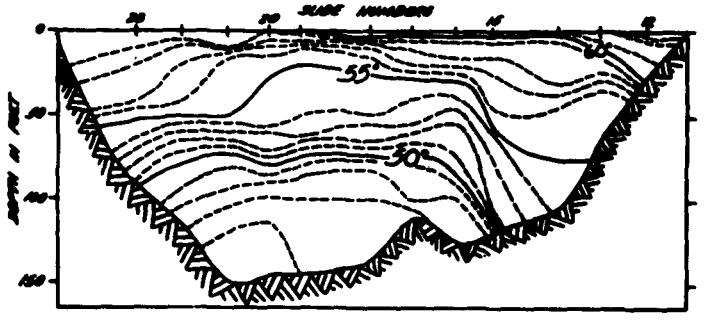
Fig. 3 Distribution of salinity (°/oo) at the surface. HAZEL III - Cruise 2, June 1951.



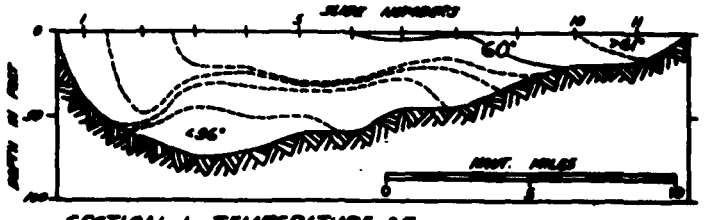
SECTION 4 , TEMPERATURE °F



SECTION 3 , TEMPERATURE °F



SECTION 2 , TEMPERATURE °F



SECTION 1, TEMPERATURE °F

Fig. 4 Distribution of temperature (°F.) along sections in Cape Cod and Massachusetts Bays. HAZEL III - Cruise 2, June 1951.

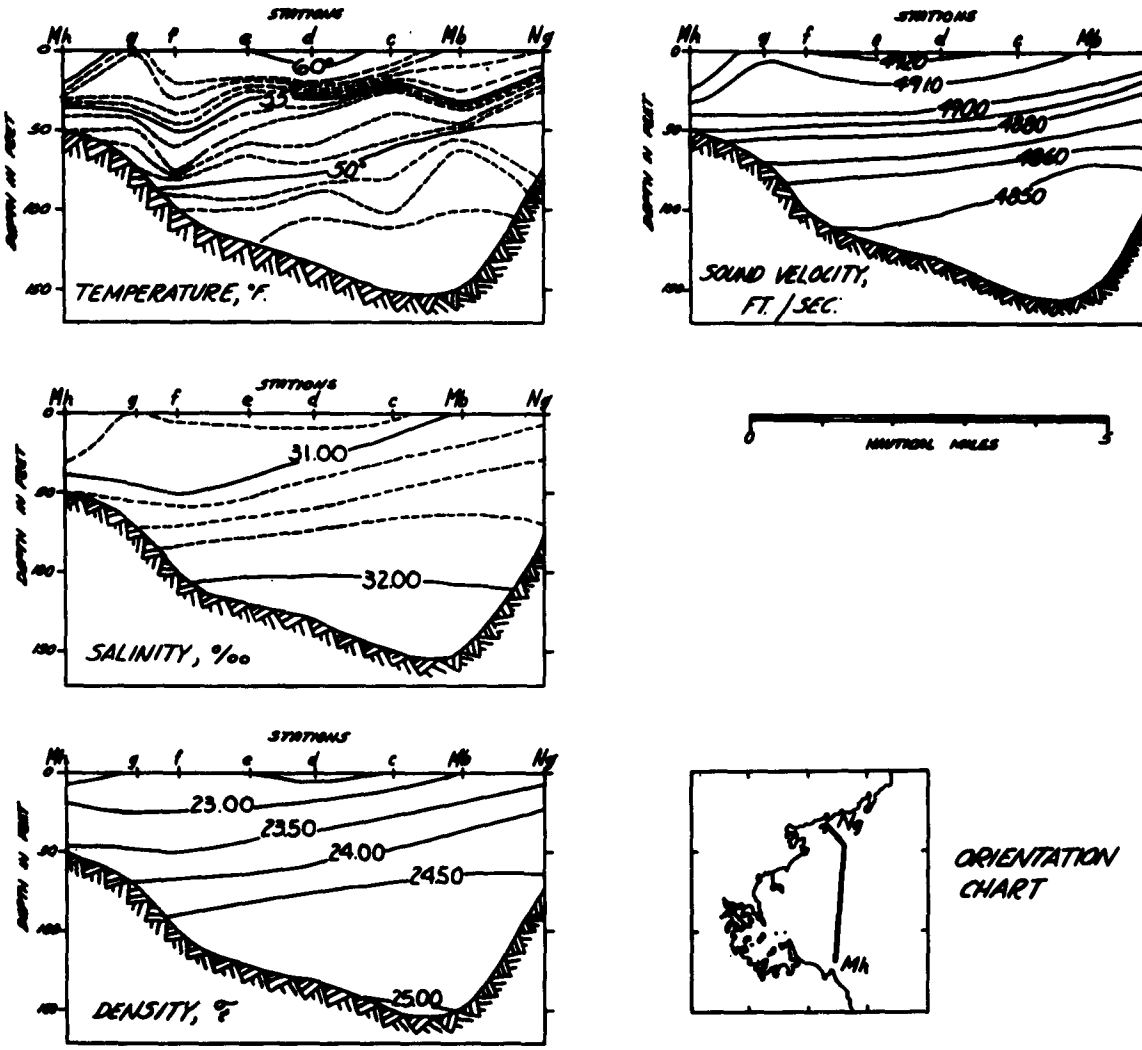


Fig. 5 Distribution of temperature, salinity, density and sound velocity in the section Minots Light to offing of Manchester. HAZEL III - Cruise 2, June 1951.

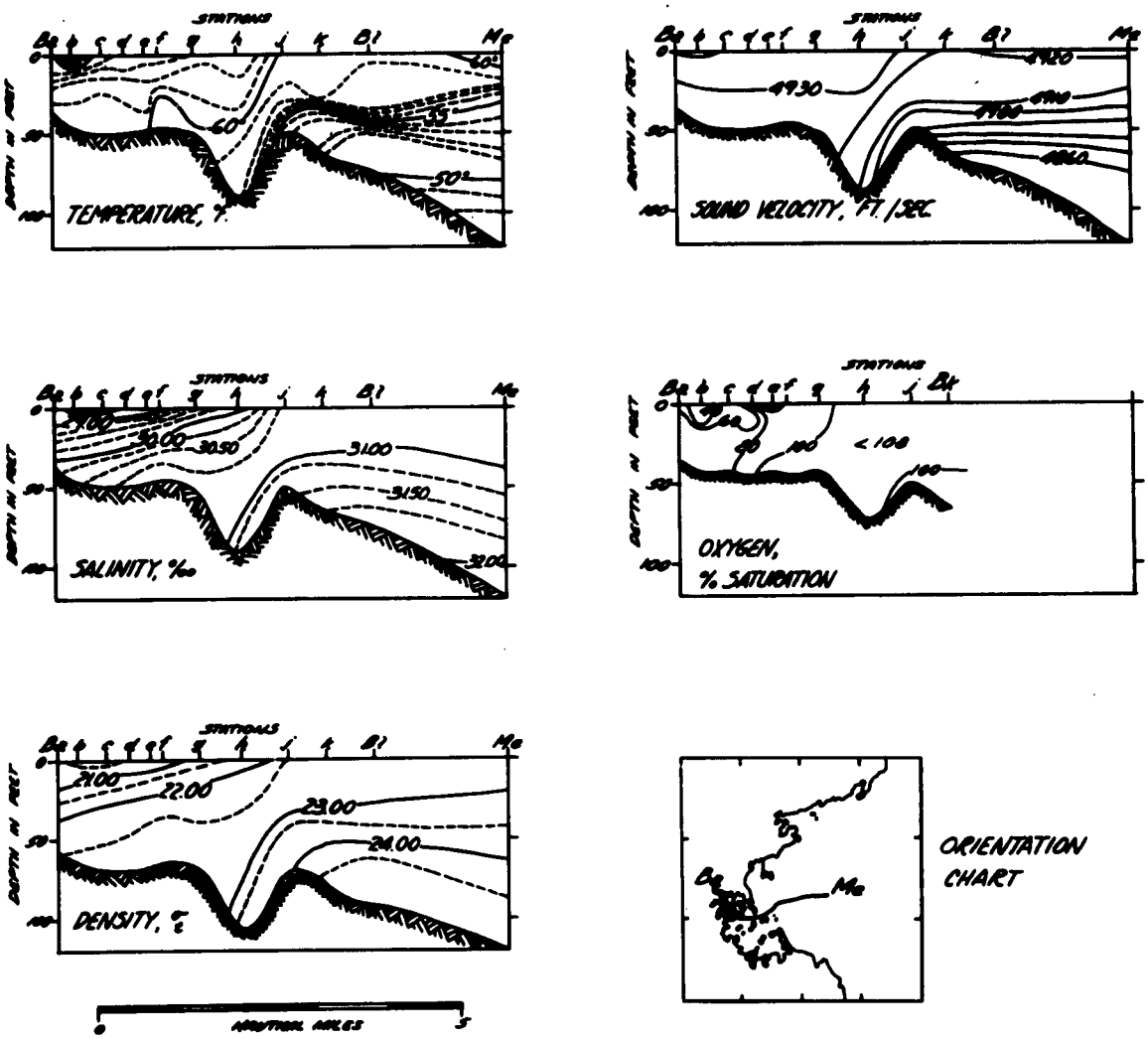


Fig. 6 Distribution of temperature, salinity, density, sound velocity and dissolved oxygen in the section Chelsea River to longitude of Boston Light Vessel. HAZEL III - Cruise 2, June 1951.

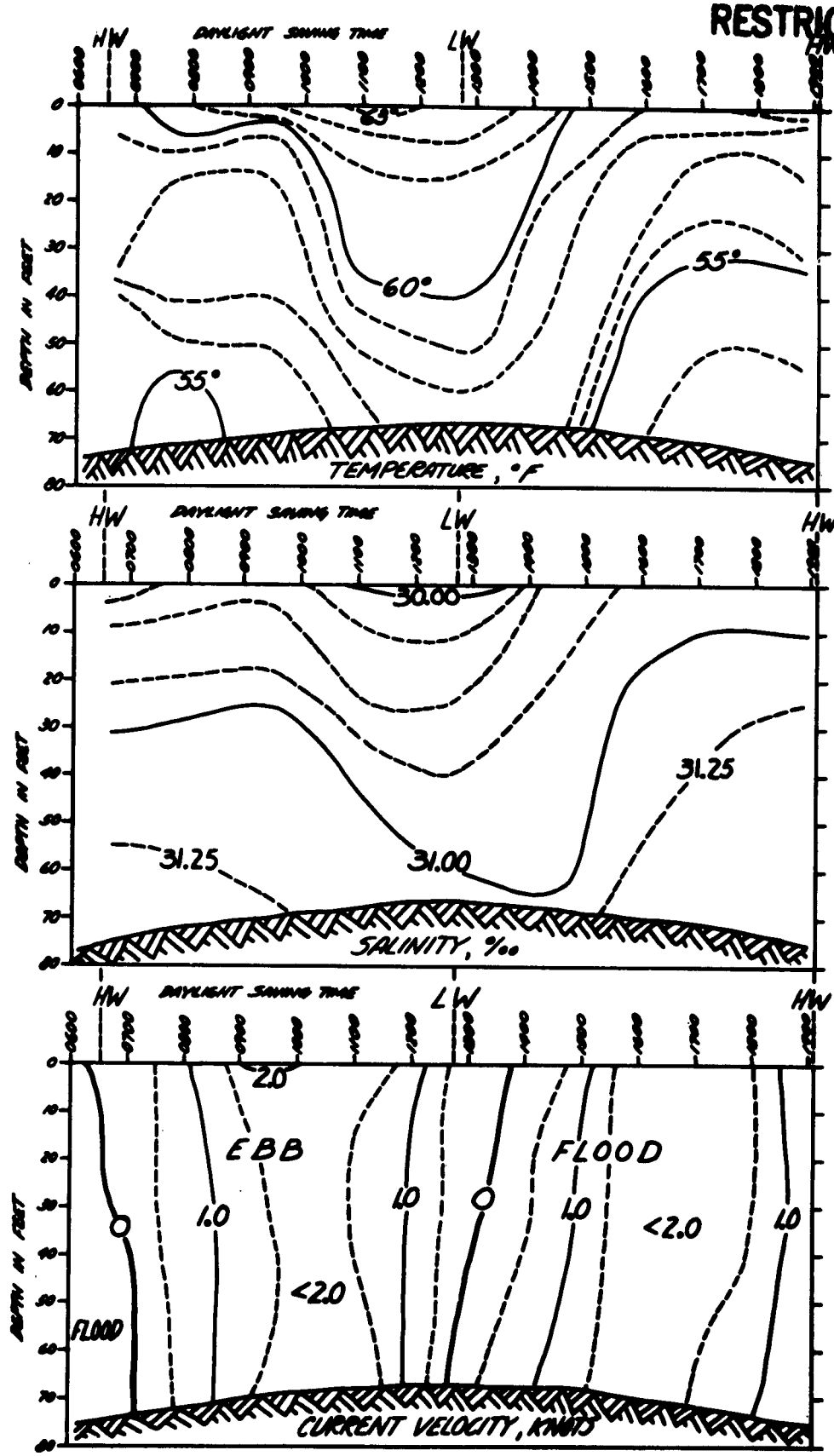


Fig. 7 Variation in the distribution of temperature, salinity and current velocity and direction during a tidal cycle, 27 June 1951 at Station Bh.

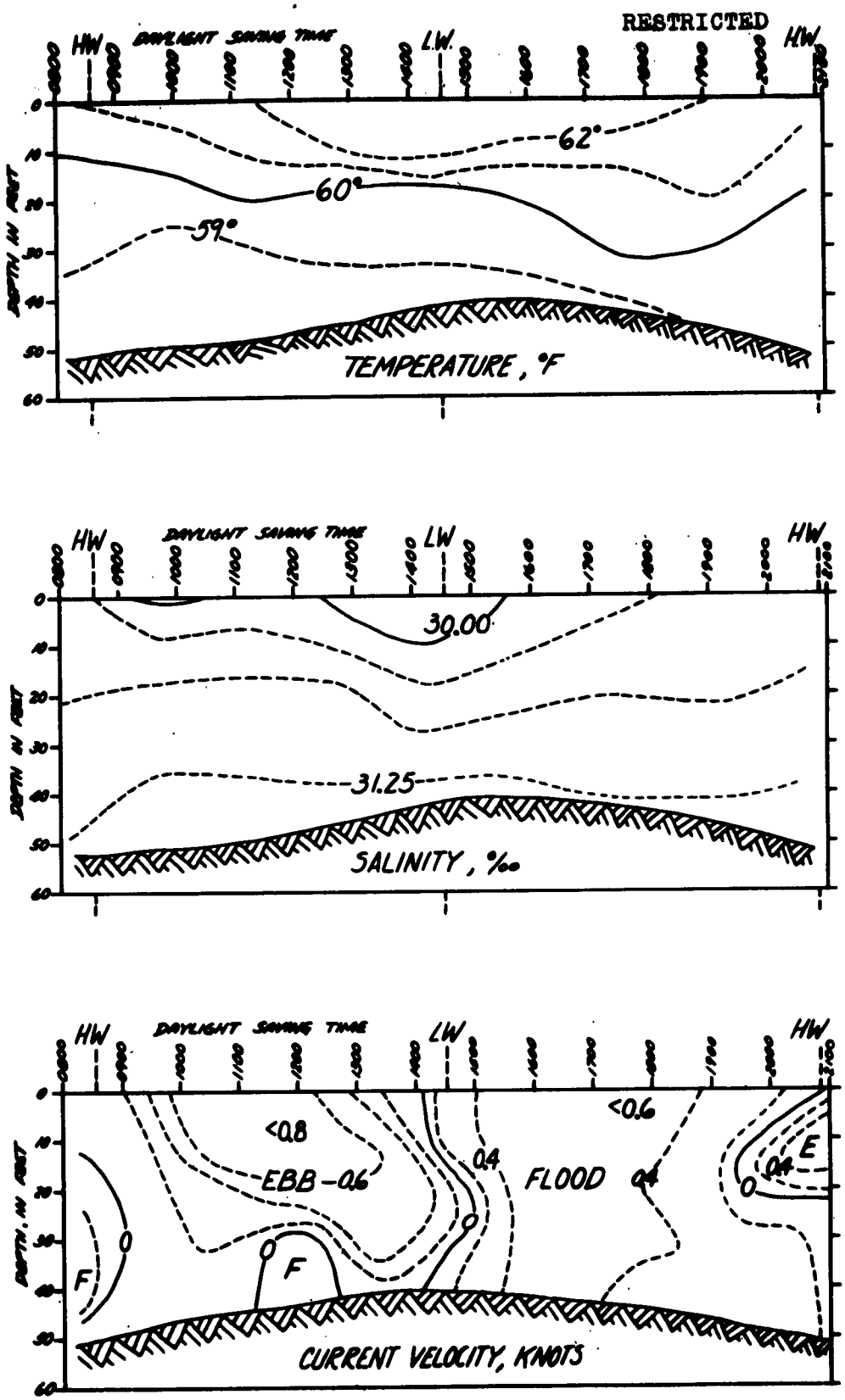


Fig. 8 Variation in the distribution of temperature, salinity and current velocity and direction during a tidal cycle, 29 June 1951 at Station Bf.

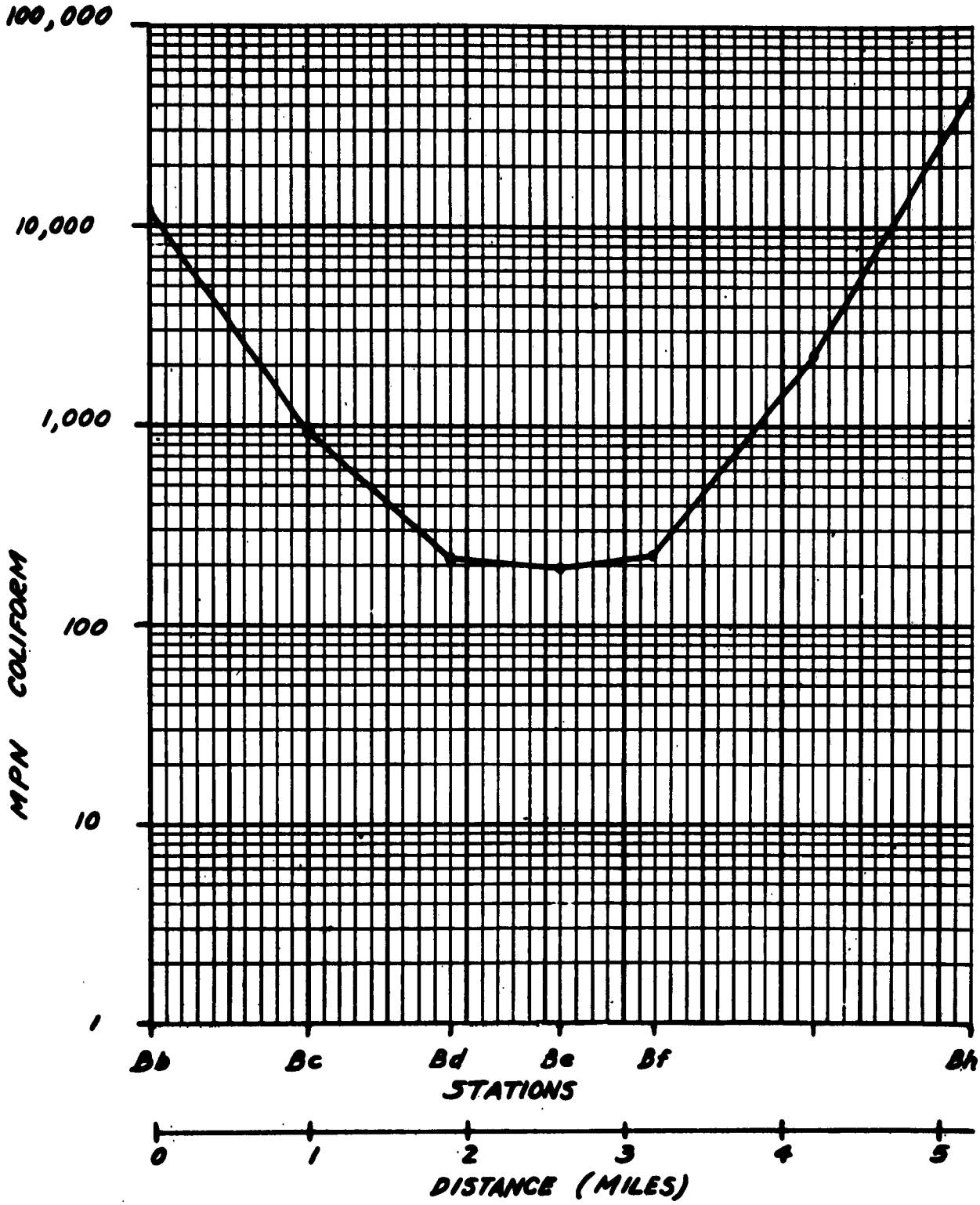


Fig. 9 Most probable number of coliform bacteria at the surface at high water at various points in Boston Harbor.

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